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Potential Uses for Woody Biomass Resources

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&

Amaron Energy

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Various Approaches for Use of Biomass in Energy Applications

- Fuel Production
  - Pyrolysis
  - Gasification
- Electricity or Steam Production
  - Biomass gasification
    - Fuel or commodity chemical production
    - steam, heat or power production
  - Co-firing w/fossil fuel (such as coal)
    - Direct co-firing
    - Pyrolysis or torrefaction followed by use of some or all pyrolysis products for direct combustion or co-firing
  - Direct biomass combustion
    - steam, heat or power production

Seeking Alternatives

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BIOMASS PYROLYSIS

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Biofuel Production from Woody Biomass Via Pyrolysis

Woody Biomass

Fast Pyrolysis

Heat in absence of oxygen. High heating rates and lower temperatures maximizes oil production.

Can recycle gas as energy input to pyrolysis unit

Pyrolysis Products

Bio-Oil

+

Bio-Char

+

Pyrolysis Gas

Fuel Oil Replacement → **Electricity, Steam/ Heat Production**

Upgrading Processes → 

Production of Transportation Fuels
Green Diesel, Gasoline & Jet Fuel

Soil amendment, CO_2 sequestration, Direct use as fuel

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Amaron Energy Process for Pyrolysis or Torrefaction of Biomass

- Traditional methods of fast pyrolysis for biomass are complex and expensive (fluid-bed technology is common).
- **Amaron Energy** (start-up company) and the University of Utah have developed a precision controlled indirectly-fired rotary kiln that achieves typical fast pyrolysis oil yields
  - Simple, inexpensive process
  - Can operate in either pyrolysis or torrefaction mode
  - Ideal candidate for remote/mobile deployment
  - Currently operating prototype facility at ½ dry ton per day (tpd) scale.
  - In design phase of 10 tpd mobile demonstration unit

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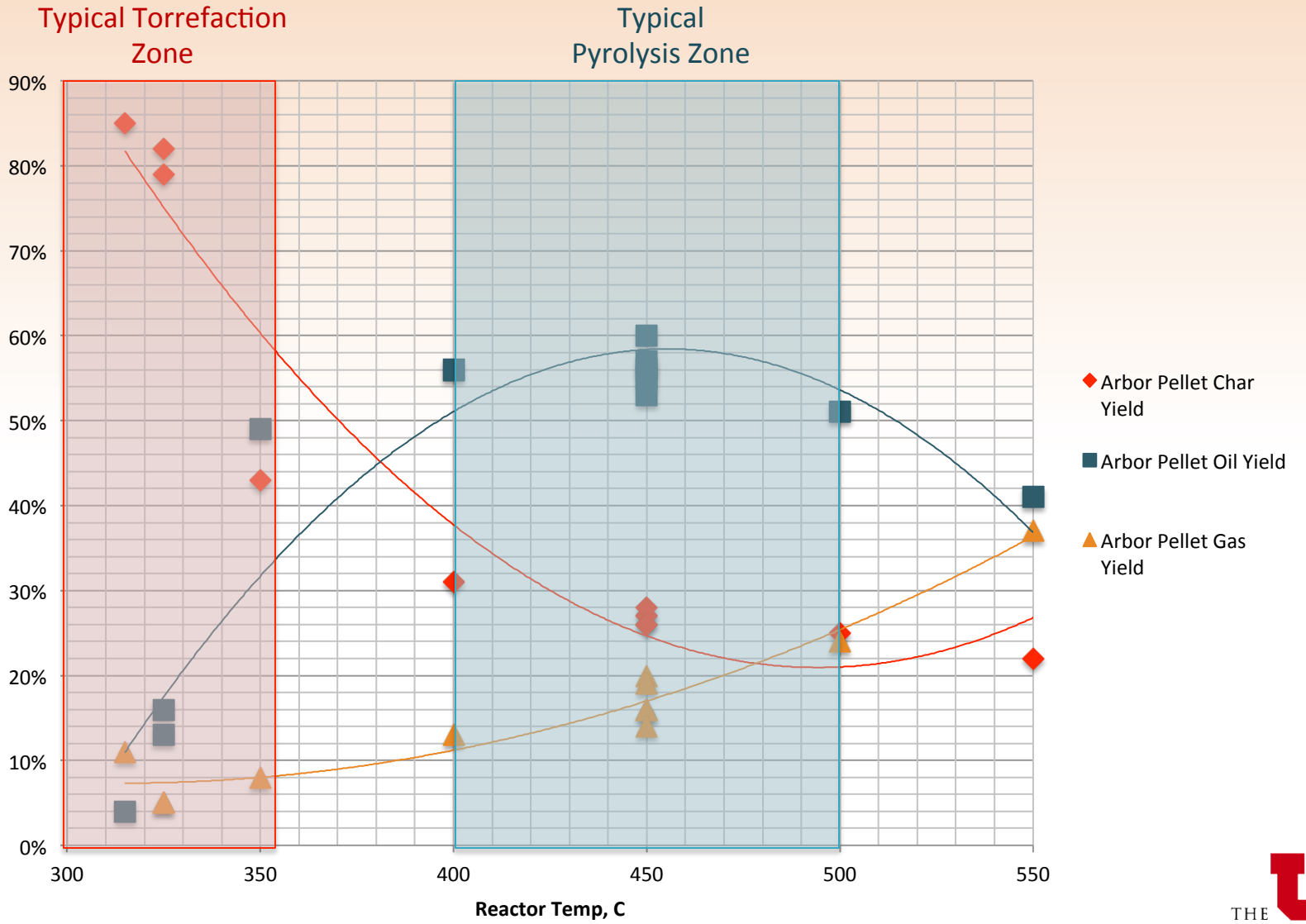
Variation of Product Yields with Reactor Temperature – Amaron Kiln Data



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Pinion-Juniper Feedstocks after Processing by Amaron Energy

Untreated wood

Torrefied wood

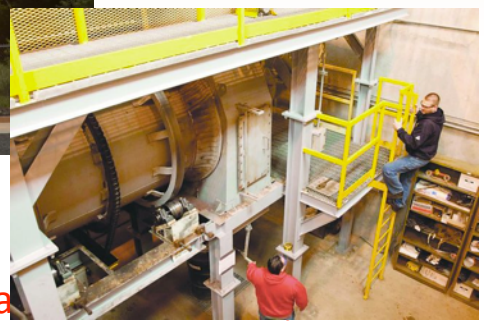
Biochar or
Pyrolyzed wood

Energy Densification: Use of Pyrolysis or Torrefaction

- Reduce costs for transporting biomass fuel by using remote pyrolysis systems to produce:
  - Higher energy density fuel
  - provides for more favorable transportation costs
- Higher energy density
  - Pyrolysis oil
    - Heating values 40-60% that of typical fuel oils, before upgrading
    - Can be fired as fuel oil substitute, or co-fired with fuel oil or coal
  - Biochar
    - Heating value ~same as coal
    - Can be co-fired with coal
  - Torrefied biomass
    - heating value ~80% of coal
    - Can be co-fired with coal

Alternative Use of Biomass Pyrolysis: Destruction of Surplus Propellant

- U.S. Army Joint Munitions Command's (JMC) Resource Recovery and Disposition Account (RRDA)
  - contain millions of lbs of excess and obsolete propellants that require disposition
- FY 2012 Information:
  - Stockpile: ~556,000 tons
  - Cost: ~$2000/ton
  - Disposition
    - 79% - Recover, Recycle, Reuse
    - 19% - Open Burn/Open Detonation
    - 2% - Contained destruction (APE 1236M2 Hazardous Wa



- Would like to recover energy content of the latter two disposition options

Destruction of Surplus Propellant: Proposed Approach

- Tooele Army Depot teams with Amaron Energy to use biomass pyrolysis technology
  - Carefully feed mixtures of propellant and biomass in Amaron Kiln
    - Ratio of biomass to propellant monitored to provide appropriate thermal input
    - Propellants of interest contain own oxidizer and will burn without additional air injection
    - Under appropriate heating conditions, propellant will heat biomass to produce oil and biochar
  - On-base dunnage (wood waste) provide biomass
    - Currently landfilled at great expense
  - Additional on-site biomass (P-J, others)

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BIOMASS GASIFICATION

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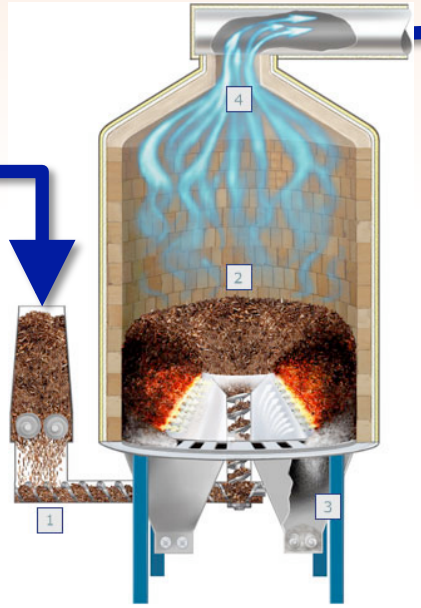
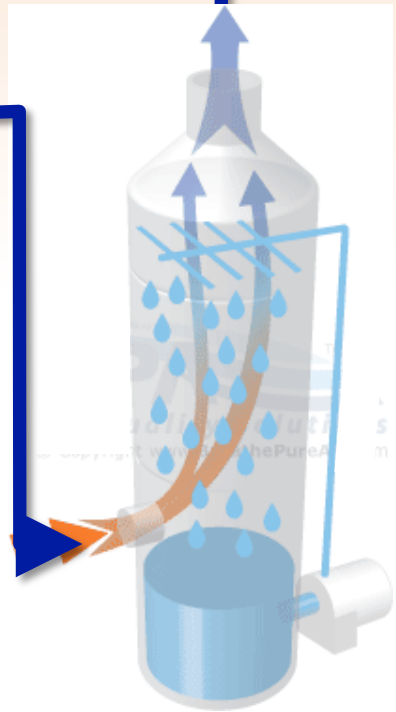
Biofuel Production via Gasification

Primarily H_2 and CO, with some CO_2 and other gases

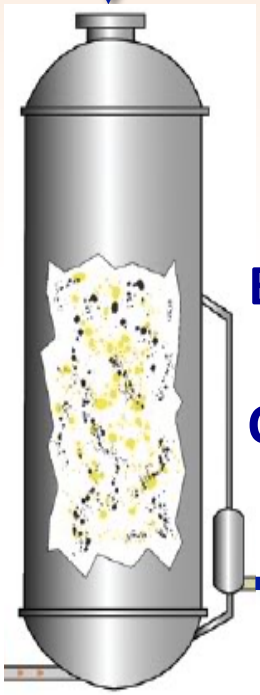
Biomass Feedstock



Biomass Gasifier (react with limited O_2)



Syngas Cleaning



Catalytic Biofuel Synthesis

Bio-derived Fuels or Commodity Chemicals

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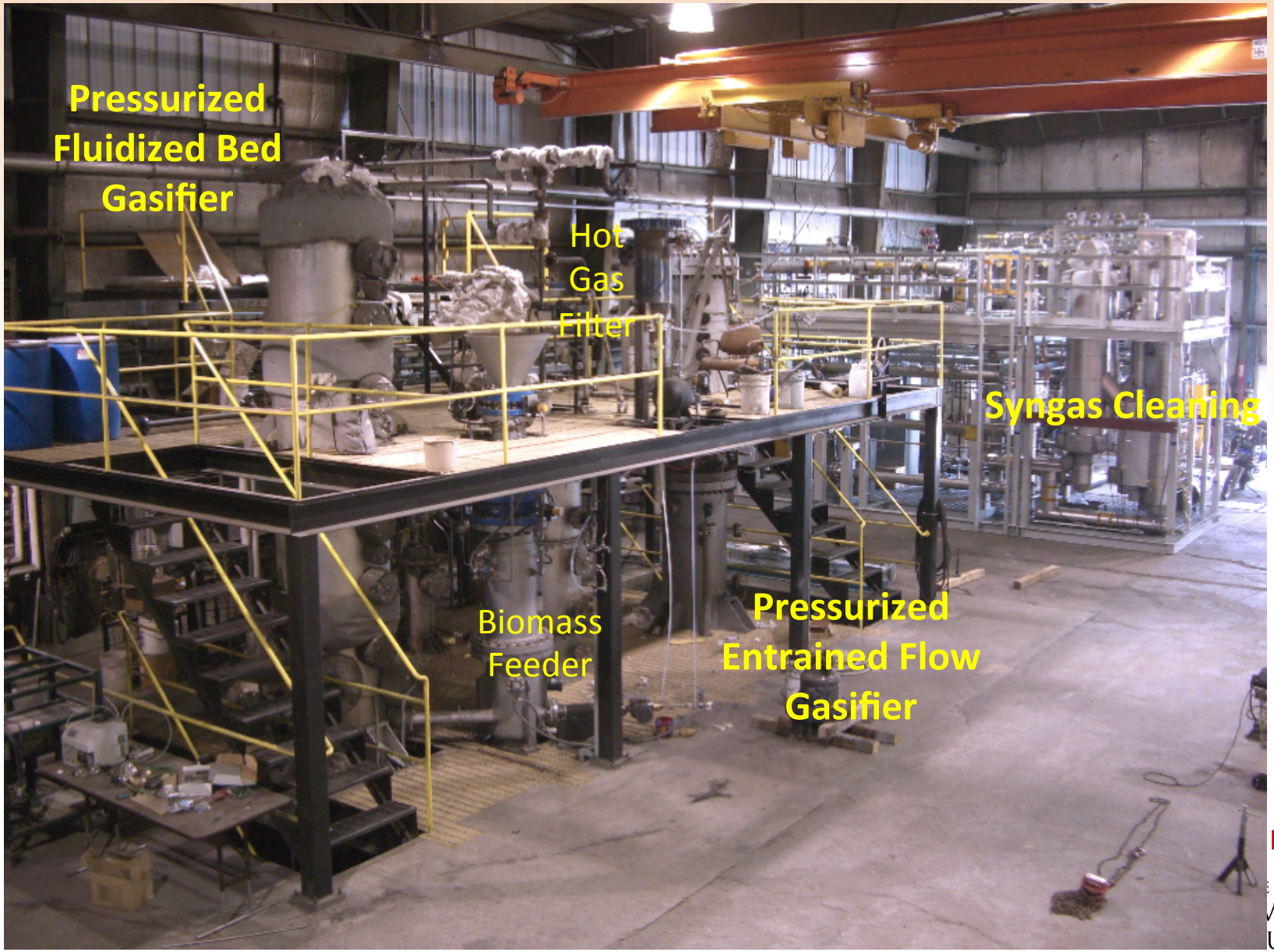
Biomass Gasification Research Laboratory at the University of Utah



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Biomass-fired Gasification

- Proposed units include fluidized-bed, entrained flow or fixed-bed units
- Availability of biomass resource will affect size
- Several pilot or demonstration units in operation or pending
- Challenges
  - Slagging/fouling on heat transfer surfaces due to high alkaline content of biomass
  - Mixing metering and distribution
    - Density, sizing, flowability
  - Tar formation and line pluggage
  - High pressure
    - Feeding, monitoring, cost

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BIOMASS CO-FIRING WITH FOSSIL FUELS

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Biomass Co-firing

- Has been tested in many full-scale utility boilers
- Similar challenges to biomass-fired units
  - Slagging/fouling on heat transfer surfaces due to high alkaline content of biomass
- Experience has indicated 10-15% biomass (on thermal input basis) is manageable from operational standpoint
- Provides opportunity to use biomass in large-scale power production, without limitations of biomass availability

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Experimental Test Campaign for Pinion/Juniper Use

- Study funded by U.S. Forest Service
- University of Utah pilot-scale test facility
  - operated to simulate operating conditions at the PacifiCorp Carbon Plant

- Fuel scenarios explored:
  - Baseline firing - Utah coal
  - Co-firing scenarios with Pinion/Juniper
    - Raw wood – 5 and 10% (based on thermal input)
    - Torrefied wood – 5, 10 and 20%
    - Pyrolyzed wood (Biochar) – 5, 10 and 20%

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Summary of Co-Firing Campaign

- Results indicated
  - essentially no major differences in gaseous emissions
  - no difference in combustion efficiency
  - no significant deposition problems using 5-10% biomass
  - Some operational/feeding issues were observed when using 10% raw wood
    - Problems were reduced with torrefied wood
    - Problems were eliminated with biochar
- Biochar clearly a good candidate for co-firing
- Primary roadblock
  - economics for biomass use w/energy densification relative to coal
    - Will improve if pyrolysis products (e.g. oil) can be used for other purposes
    - Or penalties for CO_2 emissions, or requirements for renewable fuel use

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ELECTRICITY OR STEAM HEAT PRODUCTION FROM BIOMASS

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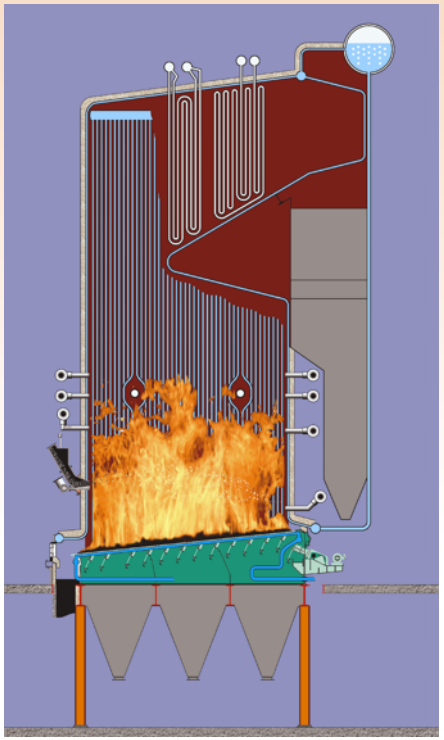
Biomass-fired Boilers

- Typically used for process steam or heat production, sometimes for power
  - Most often in 10-40 MWe range
  - Common units – grate-fired (stoker) or fluidized-bed units
  - Size is typically limited due to availability of biomass
  - Challenges
    - Slagging/fouling on heat transfer surfaces due to high alkaline content of biomass
    - Mixing metering and distribution
      - Density, sizing, flowability



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CONCLUDING COMMENTS

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Utah Pinion/Juniper Woody Biomass Utilization Team

- **Amaron Energy** – torrefaction/pyrolysis technology for biomass
- **UofU** – combustion, gasification, pyrolysis, oil upgrading
- **USU** – agronomy, land use studies, project facilitators, oil upgrading, bio-plastics
- **US Forest Service** – facilitators, funding, resource recovery
- **BLM** – facilitators, resource recovery
- **Washakie Renewable Energy** – marketing and utilization of oil
- **Tooele Army Depot** – co-pyrolysis with waste propellant
- **PacifiCorp** – Carbon Power Plant (Utah) – utilization of modified biomass for power production

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QUESTIONS?

Acknowledgement

Utah Pinion/Juniper Woody Biomass Utilization Team Members

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Dallas Hanks - Utah State University, Utah Biomass Resource Group, Amaron Energy
Darren McAvoy - Utah State University, Utah Biomass Resource Group
Scott Bell – U.S. Forest Service
Aaron Wilkerson – Bureau of Land Management
Ray Torres – Tooele Army Depot
Jacob Kingston – Washakie Renewable Energy

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